Harvey leads award-winning team to SERDP Project-of-the-Year

Dr. Benjamin Harvey, right, celebrates with his Naval Air Warfare Center Weapons Division teammates Jan. 12 in China Lake after winning the Strategic Environmental Research and Development Program 2016 Project-of-the-Year Award. From left are Dr. Lawrence Baldwin, Dr. Matthew Davis, Michael Garrison, Dr. Heather Meylemans, Dr. Thomas Groshens, Dr. Lee Cambrea, Andrew Chafin, and Harvey. (U.S. Navy photo)

NAVAL AIR WARFARE CENTER WEAPONS DIVISION, CHINA LAKE, Calif. -- In 2012, Dr. Benjamin Harvey and his team at the Naval Air Warfare Center Weapons Division, along with collaborators from the Air Force Research Laboratory at Edwards Air Force Base and the Naval Research Laboratory, were awarded a four-year grant from the Strategic Environmental Research and Development Program to develop high temperature polymers and polymer composites derived from renewable sources.

Their project titled, “Cyanate Ester Composite Resins Derived from Renewable Polyphenol Sources,” was highly successful and, on December 6, 2016, the team was honored with SERDP’s 2016 Project-of-the-Year Award for Weapons Systems and Platforms.

“I was very pleased and excited when I found out,” Harvey said. “This award is a direct result of the hard work and dedication of all the team members. We’ve had the opportunity to publish and patent a lot of paradigm-changing work in this field, but none of it would have been possible without my colleagues, the support of management and the opportunity afforded by SERDP.”

Composite materials made by combining a thermosetting resin with a rigid structural component, like carbon fiber, are widely used by the Department of Defense in place of metal or ceramic materials due to their ability to reduce weight and fuel usage. In many cases, these composites are stronger, more durable and less susceptible to corrosion than engineering metals, leading to longer life-cycles and decreased maintenance costs.

The issue, Harvey explained, is that thermosetting resins are currently derived from petroleum resources by unsustainable, energy intensive, multistep methods that utilize substantial amounts of organic solvents. To combat this, he and his project team have been working to utilize a bio-synthetic approach based on molecules like vanillin, the main component of vanilla extract, which can be produced from wood, and resveratrol, an antioxidant present in grape skins, red wine and blueberries. These natural compounds can then be converted to thermosetting resins like cyanate esters through efficient, high throughput chemistry.

“Most people assume that bio-derived materials exhibit reduced performance compared to conventional, petroleum-derived materials,” Harvey said. “In contrast, this program has shown that ‘bio-derived’ and ‘high performance’ are not mutually exclusive terms. Several of the resins developed in this project outperform conventional resins derived from petroleum.”

For example, the team has made a virtually flame-proof resin from resveratrol that has a glass transition temperature greater than 350 degrees Celsius. Small-scale testing of this material by the Federal Aviation Administration showed that it had one of the lowest heats of combustion of any polymer they’ve studied. They’ve also developed a polymer derived from pine resin that can be placed in boiling water for four days without any degradation or change in its thermomechanical properties.

According to Harvey, several of the polyphenols synthesized by NAWCWD have no estrogenic effects unlike petroleum derived resins made from Bisphenol A (BPA) and the bio-synthetic approach has the potential to offer a virtually unlimited supply of sustainable, low toxicity, bio-based polyphenols and resins for both DoD and commercial use.

Beyond the small-scale synthesis of new bio-derived molecules, Harvey and his team have fabricated and tested flat panels made with carbon fiber, glass or quartz impregnated with the resins. They have also developed new bulk molding compounds that can be

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fabricated into virtually any shape. Using this approach, the team has successfully fabricated a part that acts as a connector for a nozzle and missile case.

Harvey wasn't always interested in polymer chemistry.

"I'm a classically trained inorganic/organometallic chemist and spent most of my time in graduate school synthesizing esoteric transition metal compounds," Harvey said. "When I started working here as a postdoctoral fellow in 2006, I never thought I'd be working with bio-based polymers, but our mission is to support the warfighter and this work has the potential to make a real impact."

The SERDP yearly award recognizes scientific advances and technological solutions to some of DoD's most significant environmental challenges and looks for projects that will help DoD enhance its mission capabilities, improve its environmental and energy performance, and reduce costs. For more details on Harvey's project, visit SERDP's site at https://serdp-estcp.org/News-and-Events/Blog/Cyanate-Ester-Composite-Resins-Derived-from-Renewable-Polyphenol-Sources